**January 1995**

# Chemistry 30

## Grade 12 Diploma Examination

**Alberta**
EDUCATION

# *Chemistry 30*

## *Grade 12 Diploma Examination*

## *Description*

Time: 2.5 h. You may take an additional 0.5 h to complete the examination.

Total possible marks: 80

This is a **closed-book** examination consisting of

- 44 multiple-choice and 12 numerical-response questions each with a value of one mark

- 2 written-response questions, each worth 12 marks

This examination contains sets of related questions

A set of questions may contain multiple-choice and/or numerical-response and/or written-response questions.

When required, a grey bar will be used to indicate the end of a set.

A chemistry data booklet is provided for your reference.

The perforated pages at the back of this booklet may be torn out and used for your rough work. No marks will be given for work done on the tear-out pages.

## *Instructions*

- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.

- You are expected to provide your own scientific calculator.

- Use only an HB pencil for the machine-scored answer sheet.

- If you wish to change an answer, erase **all** traces of your first answer.

- Consider all numbers used in the examination to be the result of a measurement or observation.

- Do not fold the answer sheet.

- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education

- Read each question carefully.

- Now turn this page and read the detailed instructions for answering machine-scored and written-response questions.

## Multiple Choice

- Decide which of the choices **best** completes the statement or answers the question.

- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

### Example

This examination is for the subject of

- A. chemistry
- B. biology
- C. physics
- D. science

Answer Sheet

● Ⓑ Ⓒ Ⓓ

## Numerical Response

- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.

- If an answer is a value between 0 and 1 (e.g., 0.25), then be sure to record the 0 before the decimal place.

- **Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.**

### Examples

### Calculation Question and Solution

The average of the values 21.0, 25.5, and 24.5 is _____.
(Record your answer to three digits on the answer sheet.)

Average  = (21.0 + 25.5 + 24.5)/3
         = 23.666
         = 23.7 (rounded to three digits)

Record 23.7 on the answer sheet ⟶

| 2 | 3 | . | 7 |

## Correct-order Question and Solution

When the following subjects are arranged in alphabetical order, the order is _____.
(Record all four digits on the answer sheet.)

1 physics
2 chemistry
3 biology
4 science

Answer 3214

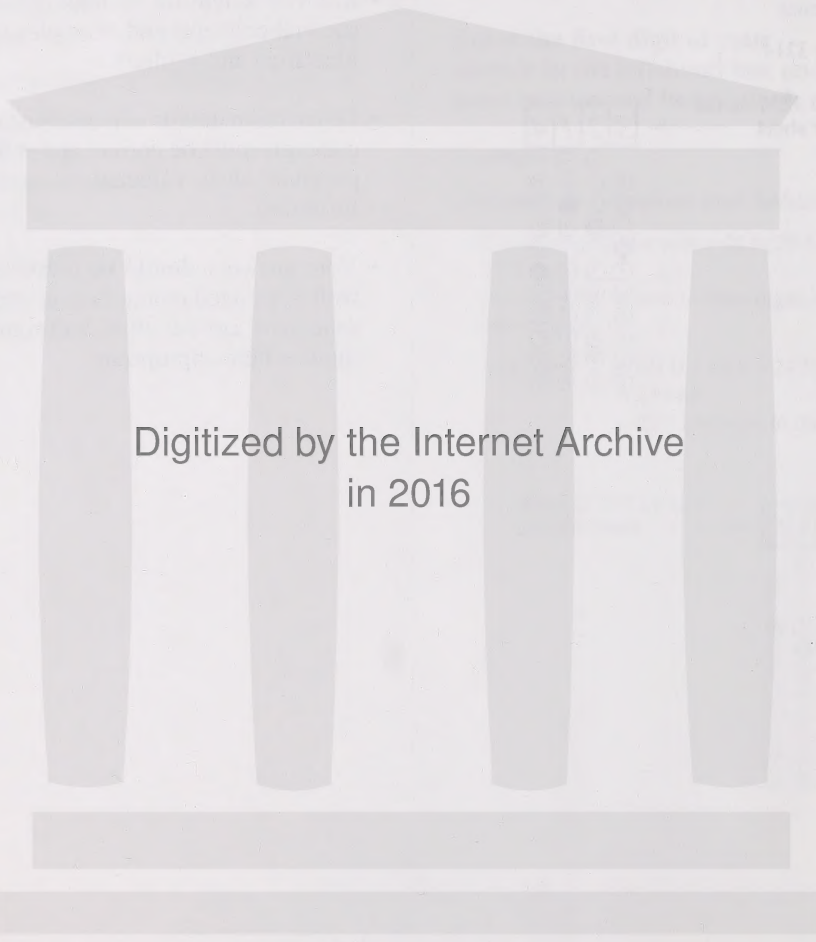**Record 3214 on the answer sheet** ➡

| 3 | 2 | 1 | 4 |
|---|---|---|---|

## Written Response

• Write your answers in the examination booklet as neatly as possible.

• For full marks, your answers must be well organized and address **all** the main points of the question.

• Relevant scientific, technological, and/or societal concepts and examples must be identified and explicit.

• Description and/or explanations of concepts must be correct and reflect pertinent ideas, calculations, and formulas.

• Your answers **should be** presented in a well-organized manner using complete sentences, correct units, and significant digits where appropriate.

*Do not turn the page to start the examination until told to do so by the presiding examiner.*

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1. Which of the following statements is **true** for an endothermic reaction?

    A. $\Delta E_p$ for the reaction is negative.
    B. Energy is a product in the chemical equation.
    C. The temperature of the surroundings increases.
    D. The potential energy of the products is greater than the potential energy of the reactants.

*Use the following information to answer the next question.*

$$4\,Q_{(s)} + Z_{2(g)} + 100\ kJ \rightarrow 2\,Q_2Z_{(g)}$$
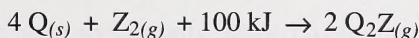
2. The $\Delta E_p$ value for the reverse reaction would be

    A. +100 kJ
    B. +50.0 kJ
    C. –50.0 kJ
    D. –100 kJ

**Numerical Response**

**1.** Benzene is a gasoline additive. The heat of formation for 1.00 mol of $C_6H_{6(l)}$ is _____ kJ. (Record your answer to three digits on the answer sheet.)

**Numerical Response**

**2.** An outdoor mercury thermometer contains 1.02 g of mercury. If, on a winter day, the thermometer records a change in temperature from –38.0°C to –13.0°C, how much energy, in joules, did the mercury absorb?
(Record your answer to three digits on the answer sheet.)

1

3. In the reaction $C_{25}H_{52(s)} + 38\,O_{2(g)} \rightarrow 25\,CO_{2(g)} + 26\,H_2O_{(g)}$ + energy, the energy released by the reaction of the paraffin fuel is called the molar enthalpy of

    A.    formation
    B.    vaporization
    C.    combustion
    D.    decomposition

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Limestone, mined near Exshaw, Alberta, is used as a raw material in the production of lime, which has a wide range of industrial applications. Lime, $CaO_{(s)}$, in the plant is produced by roasting crushed limestone, $CaCO_{3(s)}$, in kilns. The process of removing carbon dioxide from the limestone is referred to as calcination. The lime can be used to produce slaked lime, $Ca(OH)_{2(s)}$, through the careful addition of liquid water.

The demand for lime and slaked lime has increased in the last few years because it can be used in the treatment of industrial wastes and raw sewage, and in the purification of water.
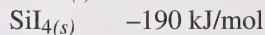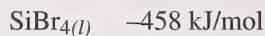
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4. The molar heat of reaction for the production of lime from limestone is

    A.    −635.1 kJ/mol
    B.    +635.1 kJ/mol
    C.    +178.3 kJ/mol
    D.    −178.3 kJ/mol

5. The production of slaked lime from lime can be classified as an

    A.    exothermic phase change
    B.    endothermic phase change
    C.    exothermic chemical change
    D.    endothermic chemical change

6. In an effort to reduce dust emissions from the plant stack, waste gases are scrubbed by adding water to trap $CaCO_{3(s)}$ and $CaO_{(s)}$ particles. This "water" is then pumped to a settling pond to allow these "wastes" to settle out. The expected pH of the settling pond is

   A. 4
   B. 6
   C. 7
   D. 12

7. A worker in the lime plant accidentally inhaled some lime dust. The taste in his mouth is expected to be

   A. sour
   B. bitter
   C. sweet
   D. salty

8. When methane is burned to heat the kiln, the

   A. oxidizing agent is reduced and loses electrons
   B. reducing agent is oxidized and gains electrons
   C. oxidizing agent is reduced and contains an element that increases in oxidation number
   D. reducing agent is oxidized and contains an element that increases in oxidation number

9. The Euglena is an organism that can produce glucose by photosynthesis when light is present. The major energy conversion in the Euglena, in the presence of light, is **best** described as

A. endothermic, with an increase in potential energy
B. exothermic, with a decrease in potential energy
C. endothermic, with an increase in kinetic energy
D. exothermic, with a decrease in kinetic energy

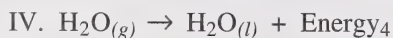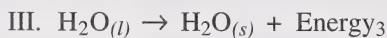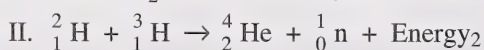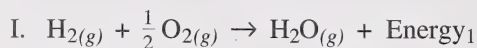*Use the following information to answer the next question.*

**Molar Heats of Formation for Silicon Halides**

| | | | |
|---|---|---|---|
| $SiF_{4(g)}$ | −1617 kJ/mol | $SiBr_{4(l)}$ | −458 kJ/mol |
| $SiCl_{4(l)}$ | −688 kJ/mol | $SiI_{4(s)}$ | −190 kJ/mol |

10. Which silicon halide is the most stable?

A. $SiF_{4(g)}$
B. $SiCl_{4(l)}$
C. $SiBr_{4(l)}$
D. $SiI_{4(s)}$

*Use the following information to answer the next question.*

I. $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(g)} + Energy_1$

II. $^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n + Energy_2$

III. $H_2O_{(l)} \rightarrow H_2O_{(s)} + Energy_3$

IV. $H_2O_{(g)} \rightarrow H_2O_{(l)} + Energy_4$

11. The **false** statement regarding the above changes is

A. $Energy_3$ is the smallest
B. reaction III represents the fusion of water
C. reaction II is a nuclear reaction
D. $Energy_1$ is greater than either $Energy_3$ or $Energy_4$

4
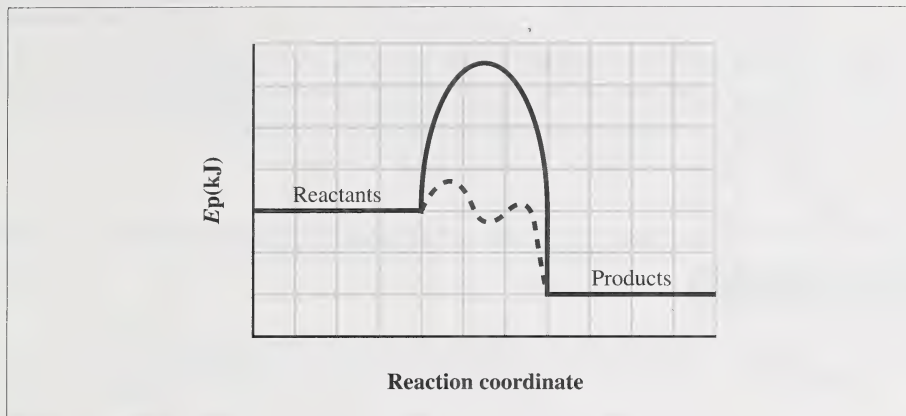
**12.** The broken line on the energy diagram indicates that

  **A.**  the temperature of the reaction has increased
  **B.**  the pressure of the system has decreased
  **C.**  more reactants have been added
  **D.**  a catalyst has been added

**13.** For which fossil fuel was the Sun the original source of energy?

  **A.**  $O_{2(g)}$
  **B.**  $CH_{4(g)}$
  **C.**  $H_{2(g)}$
  **D.**  $^{238}_{92}U_{(s)}$

**14.** All redox reactions must involve a transfer of

  **A.**  protons
  **B.**  electrons
  **C.**  neutrons
  **D.**  heat

15. $Sn^{2+}_{(aq)}$ ions are more readily reduced than

    A. $Zn^{2+}_{(aq)}$
    B. $Pb^{2+}_{(aq)}$
    C. $Cu^{2+}_{(aq)}$
    D. $Hg^{2+}_{(aq)}$

**Numerical Response**

3. The oxidation number for chlorine in $HClO_4$, $HClO$, $HClO_2$, and $Cl_2$ are respectively _____. (Record all four digits on the answer sheet.)

In a breathalyzer test, ethanol from the breath is oxidized by acidic dichromate solution in the reaction ampule. The result is a change in colour of the solution. The percentage of alcohol is determined by comparing the difference in colour between the sample that has reacted and an unreacted sample or blank. The reaction in the breath sample is

$$2 Cr_2O_7^{2-}{}_{(aq)} + 16H^+{}_{(aq)} + 3 C_2H_5OH_{(aq)} \rightarrow 4 Cr^{3+}{}_{(aq)} + 11 H_2O_{(l)} + 3 CH_3COOH_{(aq)}$$
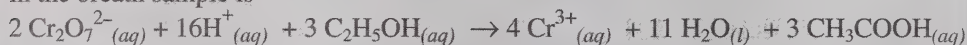
16. When alcohol from a driver's breath sample is oxidized, the reducing agent is

    A. $CH_3COOH_{(aq)}$
    B. $C_2H_5OH_{(aq)}$
    C. $Cr_2O_7^{2-}{}_{(aq)}$
    D. $Cr^{3+}{}_{(aq)}$

17. The ampule containing the acidic dichromate solution could be made of

    A. iron
    B. lead
    C. chromium
    D. glass

**4.** The electrical potential for the oxidation of ethanol by acidic dichromate is 1.75 V. The reduction potential for the ethanol half-reaction can be deduced to be −_____ V. (Record your answer to three digits on the answer sheet.)

**18.** To prevent corrosion of iron, the metal that could be connected to an underground iron fuel tank is

A. $Sn_{(s)}$
B. $Ni_{(s)}$
C. $Cu_{(s)}$
D. $Al_{(s)}$

**19.** Lonny titrates 10.0 mL of acidic tin(II) chloride solution with potassium permanganate solution. The colour change that Lonny would observe at the visual end-point is from colourless to

A. yellow
B. orange
C. pale purple/pink
D. green

**20.** Voltaic cells

A. have a positive calculated cell potential
B. convert electric energy to chemical energy
C. have a negative calculated cell potential
D. convert light energy to electrical energy

7

**21.** An experiment is designed to determine the electrical potential difference between two half-cells. One cell contains an iron strip in an iron(II) ion solution, and the other cell contains a zinc strip in a zinc nitrate solution. One of the variables that must be controlled is the

    **A.**    volume of the solutions
    **B.**    mass of the electrodes
    **C.**    concentration of the solutions
    **D.**    surface area of the metal strips

*Use the following information to answer the next question.*
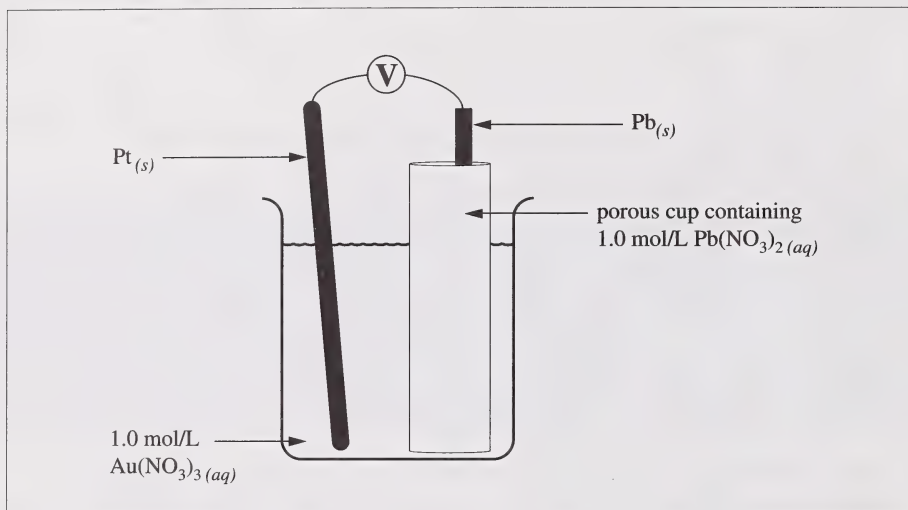


**Numerical Response**

**5.** The cell potential, under standard conditions, for the above electrochemical cell is _____ V. (Record your answer to three digits on the answer sheet.)

**Numerical Response**

**6.** A student wishes to electroplate silver onto a spoon. What current must be applied to plate 5.00 g of silver in 1.00 h? The electron flow needed is _____ A. (Record your answer to three digits on the answer sheet.)

22. In a 1.00 mol/L $H_3BO_{3(aq)}$ solution, which of the following species is present in the highest concentration before the solution is added to the nickel bath?

   A. $H_3O^+_{(aq)}$
   B. $H_2BO_3^-{}_{(aq)}$
   C. $OH^-_{(aq)}$
   D. $H_3BO_{3(aq)}$

23. Boric acid is used to maintain a pH level in the nickel plating bath:
    $H_3BO_{3(aq)} + SO_4^{2-}{}_{(aq)} \rightleftharpoons H_2BO_3^-{}_{(aq)} + HSO_4^-{}_{(aq)}$
    The addition of more $NiSO_{4(aq)}$ would

   A. increase the $[H_3BO_{3(aq)}]$ and the $[SO_4^{2-}{}_{(aq)}]$
   B. decrease the $[H_2BO_3^-{}_{(aq)}]$ and increase the $[HSO_4^-{}_{(aq)}]$
   C. increase the $[HSO_4^-{}_{(aq)}]$ and the $[H_2BO_3^-{}_{(aq)}]$
   D. decrease the $[H_2BO_3^-{}_{(aq)}]$ and the $[HSO_4^-{}_{(aq)}]$

*Use the following information to answer the next question.*

Two acids are used in the precleaning of metals to be electroplated. Bath I contains an acid with a $K_a = 1.0 \times 10^7$ and Bath II contains an acid with a $K_a = 2.2 \times 10^{-6}$.

24. If equal volumes and concentrations of the two acid cleaning solutions are compared, the acidic solution in Bath I has

   A. a higher pH
   B. more solvent molecules present
   C. fewer hydronium ions in solution
   D. fewer undissociated acid molecules

9

25.  In order to maintain the pH in an electroplating bath, strong acids are added. If a 10 L sample of 1.0 mol/L $HCl_{(aq)}$ is added to 990 L of water, the pH of the $HCl_{(aq)}$ is

A.  increased by 2 pH units
B.  increased by 1 pH unit
C.  decreased by 2 pH units
D.  decreased by 1 pH unit

26.  In industry, some of the empirical properties of a substance are selected as safe and efficient diagnostic tests. In the electroplating industry, the **safest** and **most efficient** diagnostic test for acids is the one where

A.  acids taste sour
B.  blue litmus turns red in acid solution
C.  acids react with active metals to produce hydrogen gas
D.  acids react with carbonates to produce carbon dioxide gas

27.  A solution that could be used for a rinse bath to neutralize any acid on a plated object is

A.  $NaCH_3COO_{(aq)}$
B.  $NH_4Cl_{(aq)}$
C.  $KNO_{3(aq)}$
D.  $HOCl_{(aq)}$

Chromium(VI) oxide is used to form the highly acidic "chromic acid" in chromium plating solution. Production of "chromic acid" is $2 CrO_{3(s)} + H_2O_{(l)} \rightarrow H_2Cr_2O_{7(aq)}$. The "chromic acid" ionizes 100% in water as $H_2Cr_2O_{7(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + HCr_2O_7^-_{(aq)}$.

28. What is the pH in a chromium plating solution in a 1000 L tank when 240.0 g/L of $CrO_{3(s)}$ is dissolved?

   A.  −0.0792
   B.  −0.3802
   C.  2.620
   D.  2.921

29. Barium carbonate is used to modify the pH in chromium plating solutions. The addition of solid barium carbonate

   A.  decreases the pH and decreases the $[H_3O^+_{(aq)}]$
   B.  decreases the pH and increases the $[H_3O^+_{(aq)}]$
   C.  increases the pH and increases the $[H_3O^+_{(aq)}]$
   D.  increases the pH and decreases the $[H_3O^+_{(aq)}]$

11

The Haber process uses hydrogen and nitrogen to produce ammonia for use as a feedstock for other processes or as a fertilizer. In industry, the goal of manufacturing is to obtain the highest yield of product for the lowest cost.

30. The equation for the equilibrium reaction is

A. $N_{2(g)} + 3\,H_{2(g)} \rightleftharpoons 2\,NH_{3(g)} + 92.2\,kJ$

B. $N_{2(g)} + 3\,H_{2(g)} + 92.2\,kJ \rightleftharpoons 2\,NH_{3(g)}$

C. $2\,NH_{3(g)} \rightleftharpoons N_{2(g)} + 3\,H_{2(g)} + 46.1\,kJ$

D. $2\,NH_{3(g)} \rightleftharpoons N_{2(g)} + 3\,H_{2(g)} \qquad \Delta E_p = -46.1\,kJ$

31. The equilibrium expression for this process is

A. $K_{eq} = \dfrac{[NH_{3(g)}]}{[N_{2(g)}][H_{2(g)}]}$

B. $K_{eq} = \dfrac{[NH_{3(g)}]^2}{[N_{2(g)}][H_{2(g)}]^3}$

C. $K_{eq} = \dfrac{[N_{2(g)}]3[H_{2(g)}]}{2[NH_{3(g)}]}$

D. $K_{eq} = \dfrac{[N_{2(g)}][H_{2(g)}]}{[NH_{3(g)}]}$

32. Ammonia could also be produced industrially, by reacting ammonium ion with hydrogen sulphate ion according to the equation

$$NH_4^+{}_{(aq)} + HSO_4^-{}_{(aq)} \rightleftharpoons NH_{3(aq)} + H_2SO_{4(aq)}.$$
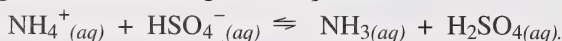
A conjugate acid base pair is

A. $NH_4^+{}_{(aq)}$ and $HSO_4^-{}_{(aq)}$

B. $HSO_4^-{}_{(aq)}$ and $NH_{3(aq)}$

C. $H_2SO_{4(aq)}$ and $HSO_4^-{}_{(aq)}$

D. $H_2SO_{4(aq)}$ and $NH_4^+{}_{(aq)}$

33. Fertilizer can then be produced by reacting aqueous ammonia with nitric acid. The correct net ionic equation for this process is

A. $NH_{3(aq)} + H_3O^+{}_{(aq)} \rightarrow NH_4^+{}_{(aq)} + H_2O_{(l)}$

B. $NH_{3(aq)} + H_2O_{(l)} \rightarrow NH_2^-{}_{(aq)} + H_3O^+{}_{(aq)}$

C. $NH_{3(aq)} + HNO_{3(aq)} \rightarrow NH_4^+{}_{(aq)} + NO_3^-{}_{(aq)}$

D. $H_3O^+{}_{(aq)} + NO_3^-{}_{(aq)} \rightarrow HNO_{3(aq)} + H_3O^+{}_{(aq)} + NH_4^+{}_{(aq)}$

**34.** A 0.100 mol/L propanoic acid solution, $C_2H_5COOH_{(aq)}$, has a pH of 2.95. From these data, the $K_b$ for the propanoate ion, $C_2H_5COO^-_{(aq)}$, is

A.  $1.1 \times 10^{-3}$
B.  $1.3 \times 10^{-5}$
C.  $7.9 \times 10^{-10}$
D.  $8.7 \times 10^{-12}$

## Numerical Response

**7.** At a specific temperature, a chemist measured the equilibrium concentrations of all the species for the reaction $H_{2(g)} + F_{2(g)} \rightleftharpoons 2\,HF_{(g)}$. The measured concentrations were: $[H_{2(g)}]_{(eq)} = 0.471$ mol/L, $[F_{2(g)}]_{(eq)} = 0.471$ mol/L, $[HF_{(g)}]_{(eq)} = 0.506$ mol/L. The equilibrium constant for this system at the specified temperature is _____. (Record your answer to three digits on the answer sheet.)
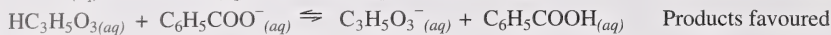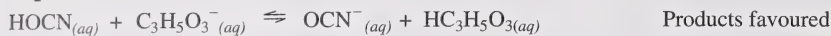
## Numerical Response

**8.** The pH of a solution with a pOH of 6.95 is _____. (Record your answer to three digits on the answer sheet.)

**35.** Which of the following is **not** associated with a 0.10 mol/L solution of a weak acid?

A.  $[H_3O^+_{(aq)}] < 0.10$ mol/L
B.  pH = 1.00
C.  A small $K_a$ value.
D.  A relatively strong conjugate base.

**Equations**

$HOCN_{(aq)} + C_3H_5O_3^-{}_{(aq)} \rightleftharpoons OCN^-{}_{(aq)} + HC_3H_5O_{3(aq)}$      Products favoured

$HC_3H_5O_{3(aq)} + C_6H_5COO^-{}_{(aq)} \rightleftharpoons C_3H_5O_3^-{}_{(aq)} + C_6H_5COOH_{(aq)}$      Products favoured

$HOCN_{(aq)} + IO_3^-{}_{(aq)} \rightleftharpoons OCN^-{}_{(aq)} + HIO_{3(aq)}$      Reactants favoured

**Key**

| | | | |
|---|---|---|---|
| 1   $C_6H_5COOH_{(aq)}$ | 4   $OCN^-{}_{(aq)}$ | 7   $HC_3H_5O_{3(aq)}$ |
| 2   $C_6H_5COO^-{}_{(aq)}$ | 5   $HIO_{3(aq)}$ | 8   $C_3H_5O_3^-{}_{(aq)}$ |
| 3   $HOCN_{(aq)}$ | 6   $IO_3^-{}_{(aq)}$ | |

**Numerical Response**

**9.** The bases, listed in any order, are _____.
(Record all numbers in your sequence on the answer sheet.)

**Numerical Response**

**10.** The acids, ordered from strongest to weakest, are _____.
(Record all numbers in your sequence on the answer sheet.)

**36.** A drop of chlorophenol red is added to a 0.10 mol/L $HCl_{(aq)}$ sample. The colour of the indicator is

A. yellow because the pH of the solution is less than 5.2
B. yellow because the pH of the solution is greater than 5.2
C. red because the pH of the solution is less than 6.8
D. red because the pH of the solution is greater than 6.8

**37.** Which of the following species is able to react as either an acid or a base?

**A.** $CO_3^{2-}{}_{(aq)}$
**B.** $CH_3OH_{(aq)}$
**C.** $HS^-{}_{(aq)}$
**D.** $NH_{3(aq)}$

*Use the following information to answer the next two questions.*

A student is asked to determine the molar concentration of acetic acid in a sample of vinegar. A standardized sodium hydroxide solution is available. From the list below, select the four procedures you would most likely perform to solve this problem.

1     measure and record the initial mass of the vinegar sample
2     measure and record the volume of the vinegar sample
3     add phenolphthalein to the vinegar sample
4     fill a buret with standardized sodium hydroxide solution
5     measure and record the final mass of the vinegar sample
6     measure and record the initial and final volumes from the buret

**Numerical Response**

**11.** The four procedures, in any order, are _____.
(Record all four digits on the answer sheet.)

**Numerical Response**

**12.** The order in which these procedures must be performed is _____.
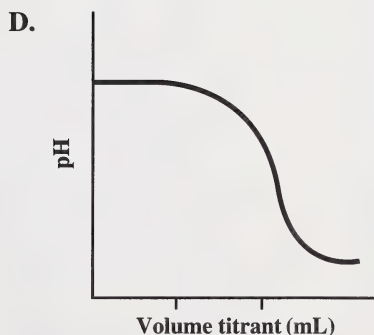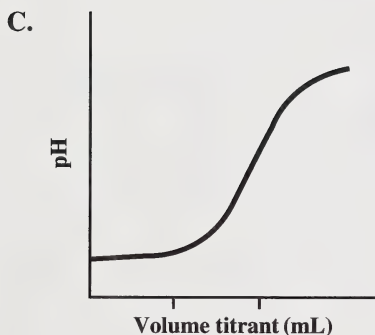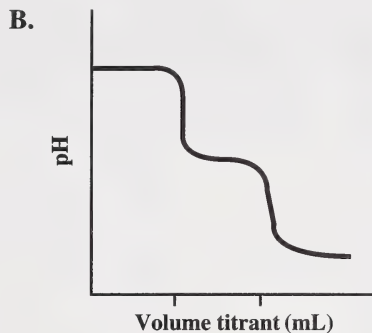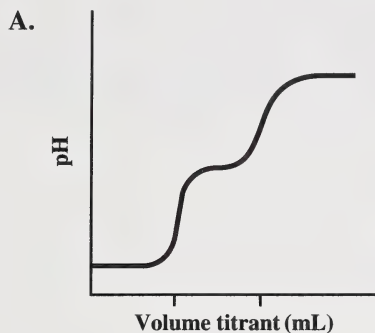(Record all four digits on the answer sheet.)

**38.** A buffer system of $CH_3COOH_{(aq)}$ / $NaCH_3COO_{(aq)}$ works best if

    **A.**    the solution to be buffered has a pH greater than 7

    **B.**    the amount of $CH_3COOH_{(aq)}$ and $CH_3COO^-_{(aq)}$ are large compared to the amount of acid or base added

    **C.**    large amounts of acid or base are added to the buffered system

    **D.**    the concentration of $CH_3COO^-_{(aq)}$ is small compared to the concentration of $CH_3COOH_{(aq)}$

*Use the following information to answer the next question.*



Volume of acid (mL)
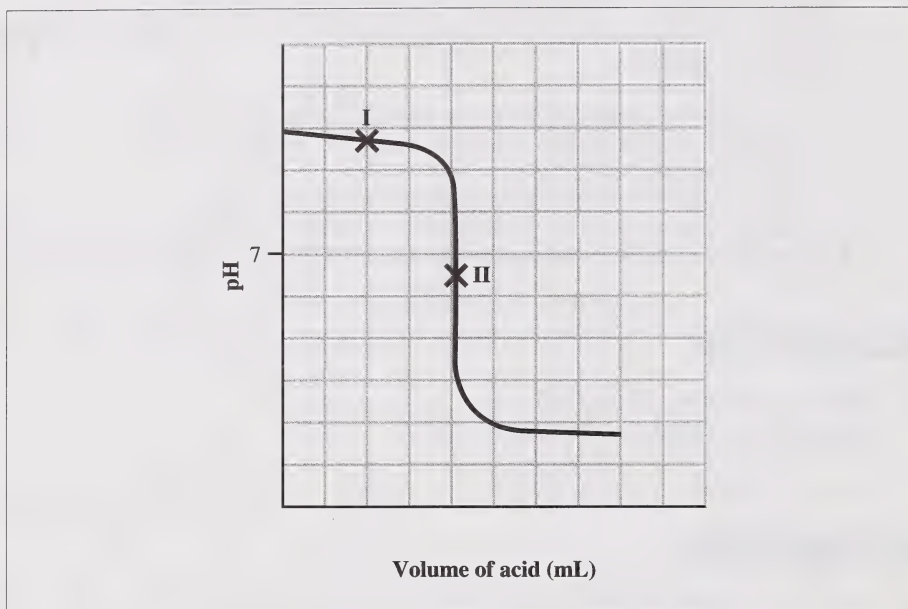
**39.** On the pH curve showing the titration of a weak base with a strong acid, it can be seen that the pH changes very gradually at I compared to II. The reason for this is that

    **A.**    the acid is not as strong at I as at II

    **B.**    the solution at I is a buffer solution

    **C.**    all the base reacted at I

    **D.**    pH always changes rapidly around pH = 7

16

**40.** Which of the following graphs **best** represents the neutralization of a diprotic acid by the continuous addition of 0.10 mol/L NaOH$_{(aq)}$?

A.



Volume titrant (mL)

B.



Volume titrant (mL)

C.



Volume titrant (mL)

D.



Volume titrant (mL)

**41.** The volume of 0.120 mol/L hydrobromic acid required to neutralize 40.0 mL of 2.8 mol/L NaOH$_{(aq)}$ is

A. 1.1 L
B. 0.93 L
C. 0.11 L
D. 0.013 L

42. A drop of methyl orange added to an unknown solution produces a yellow colour. The most precise prediction that can be made is that the pH of the solution is

A. greater than 7.0
B. between 3.2 and 4.4
C. greater than 4.4
D. between 4.4 and 7.0

43. The point on the titration curve that indicates neutralization of the acid is



Volume of base added
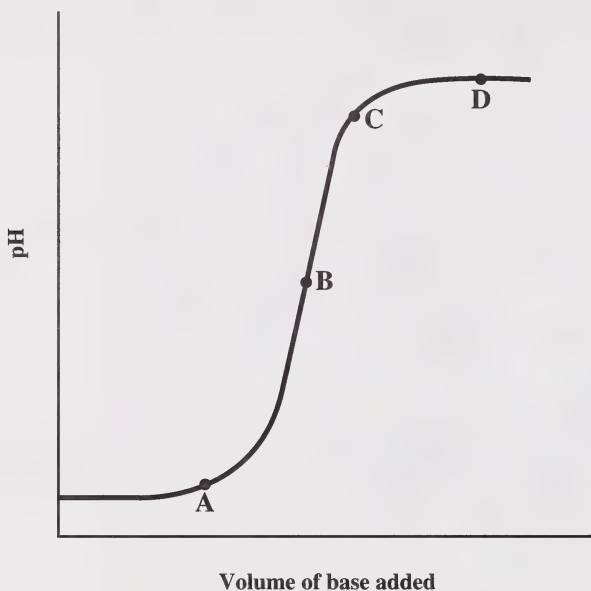
44. An important part of the buffer in blood is the

A. hydrogen carbonate ion
B. acetate ion
C. ethanoate ion
D. ammonium ion

18

1. A student suspects that the electrical potential difference available from a voltaic cell may be affected by the concentration of the solutions used in the half-cells. Using commonly available laboratory apparatus, design an experimental procedure to test this hypothesis. Specify in your design which variables could be identified as controlled, manipulated, and responding.
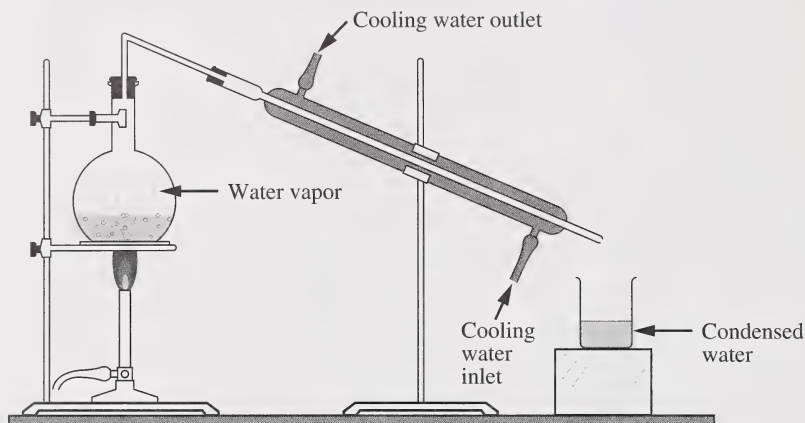
Written Response – 12 marks

*Use the following information to answer the next question.*

The simple condenser below is used to condense steam. The various operating temperatures were recorded.

| | |
|---|---|
| temperature of steam | 98.0°C |
| temperature of condensed water | 68.0°C |
| initial temperature of cooling water | 22.0°C |
| final temperature of cooling water | 68.0°C |



2. **a.** How much energy is removed by the **cooling** water if 1.25 kg of **condensed** water is collected?

**b.** Name one industry that would use this type of "technology" and the product(s) it would produce.

**c.** What environmental issue is related to this "technology," and why is it a concern?

*You have now completed the examination.*
*If you have time, you may wish to check your answers.*

# Chemistry 30
## January 1995

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